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Master Thesis

Exploring the predictors of vaccination completeness in the first year of life. Analysis of a community-based household survey in Eastern Uganda

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"I hereby certify that I formulated the research question, performed the literature review used in this report, developed and implemented the study design, analyzed the data, and interpreted the results. I also confirm that the project presented reflects my own work, that the report was written using my own ideas and words, and that I am the only person held responsible for its contents. All sources of information, printed or electronic, reported by others are indicated in the list of references in accordance with international guidelines."

ABSTRACT

Background: Only 4 in 10 children in Uganda are fully vaccinated by the first year of life, despite its clear benefits in averting millions of deaths. Major determinants and barriers to higher coverage levels of vaccination remain unknown in the rural settings in Uganda. This study sought to explore the effect of the mothers' social, individual and health system factors on complete vaccination coverage among children aged 12 to 23 months in Eastern Uganda.

Methods: This study used data from the Expanded Quality Management Using Information Power (EQUIP) project. Continuous health facility censuses and repeated probability sample household surveys organized in six rounds were implemented between 2011 and 2014. Identified resident women of reproductive age with a live birth since 2010 were interviewed on care received during ante-, peri- and postpartum including immunization. Personal digital assistants were used to capture data and completion of interviews was 91% in Uganda. The main outcome indicator was the proportion of one year olds who had received BCG, Polio (3 times), DPT (3 times) and Measles (once) in their first year of life. Explanatory variables were the age group, wealth, level of education, religion, place of birth, distance from the health center, house hold members and antenatal care attendance. Mother's ability to get; permission from their husbands, money and transport to facility, good health worker's attitude, vaccine stock-out levels, and preference for traditional medicine were also assessed.

Analysis: The analysis included bivariate and multivariate analysis. Explanatory variables which had an association with the outcome indicators with a P value less than 0.2 were included in the logistic regression models, adjusting for clustering.

Results: Overall vaccination coverage was 46%. Coverage in children aged 12-23 months was 97% for BCG, 67% for DPT, 40% for Polio and 59% for Measles. Maternal age above 20 years (OR=1.4, P=0.02), attendance of antenatal care (OR=1.7, P=0.01), delivery at a health facility (OR=1.5, P=0.00), shorter distance between home and health facility (OR=2.1, P=0.00) were significant positive predictors of immunization completeness in the first year of life but absolute differences were small.

Conclusion: The high vaccination drop outs during the first year are calling for interventions to improve adherence to vaccination schedules and to strengthen information on vaccination at all contact opportunities along the continuum of care.

Keywords: EQUIP, Vaccination, DPT, Measles, Polio, BCG, Predictors, Uganda, Namayingo, Mayuge.

TABLE OF CONTENTS:

ABSTRACT.....	ii
LIST OF ABBREVIATIONS AND GLOSSARY.....	iv
INTRODUCTION.....	1
BACKGROUND	
Uganda.....	3
State of vaccination.....	4
Conceptual framework.....	6
Research question.....	7
Main Aim and specific objectives.....	7
METHODOLOGY	
Study design.....	8
Study setting.....	9
Flow chart of study participants	11
Data management and analysis.....	12
RESULTS	
General characteristics of study.....	13
Determinants of vaccination coverage.....	15
Regression.....	17
DISCUSSION.....	20
Strengths and limitations.....	22
Conclusions and recommendations.....	22
ACKNOWLEDGEMENTS.....	23
REFERENCES.....	24
ANNEXS.....	26

LIST OF ABBREVIATIONS AND GLOSSARY

AIDS: Acquired Immune Deficiency Syndrome

BCG: Bacillus Calmette-Guérin

CI: Confidence Interval

DHS: Demographic Health Survey

DPT: Diphtheria-Pertussis-Tetanus

EQUIP: Expanded Quality Management Using Information Power.

GAVI: The Global Alliance for Vaccines and Immunizations

GVAP: Global Vaccine Action Plan

HIV: Human Immunodeficiency Virus

HSSP: Health Sector Strategic Plan

MHCP: essential / minimum health care package

MoH: Ministry of Health

OR: Odds Ratio

PHC: Primary Health Care

SPSS: Statistical Package for the Social Sciences

UNEPI: Uganda National Expanded Programme on Immunization

UNICEF: United Nations Children's Fund

WHO: World Health Organization

INTRODUCTION

Child Health

Despite the declining trends, 6.3 million children still die globally before their 5th birthday (1). It does not only preserve human dignity and equality (2), but also reduction of child mortality has far reaching benefits, presumptions that would actually stabilize the alarming fertility rates in Sub-Saharan Africa.

In this regard, families have had to resort to having more children considering the fact that one in every 10 children dies before five years of age. In these areas, there is an evident correlation between global fertility rates and child mortality (3), a phenomenon that has dominated low income countries for decades.

Acute respiratory infections, diarrhea, malaria, HIV/AIDS and malnutrition dominate the continuum of causes whose ultimate solution dwells on the nations' capacity to provide prevention mechanisms to these causes. For more than 20 years, these conditions have claimed millions of children's lives in Sub-Saharan Africa despite the focused vaccination schedules that have been instituted.

Vaccination

WHO defines immunization as, "the process whereby, a person is made immune or resistant to an infectious disease typically by the administration of a vaccine." Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease (4).

In this process (5), vaccines expose you to a very small and safe amount of viruses or bacteria that have been either weakened (attenuated) or killed (inactivated). "Others like the diphtheria and tetanus vaccines are made from toxins or chemicals from the bacteria or virus.

Biosynthetic vaccines like haemophilus influenza type B are man-made substances, similar to the piece of virus or bacteria" (4).

These vaccines play a role of protection against potentially life threatening illnesses that include; tetanus, diphtheria, mumps, measles, pertussis (whooping cough), meningitis and polio (2). "Vaccines are one of the most successful and cost-effective investment in history. By helping healthy people stay healthy, vaccines remove a major barrier to human development. Immunized children have higher cognitive abilities and are more likely to attend school and go on to be productive members of their community" (5).

Immunization is “a proven tool for controlling and eliminating life-threatening infectious diseases and is estimated to avert between 2 and 3 million deaths each year. It is one of the most cost-effective health investments, with proven strategies that make it accessible to even the most hard-to-reach and vulnerable populations. It has clearly defined target groups, can be delivered effectively through outreach activities and does not require any major lifestyle change” (4).

Under the leadership of the World Health Organization (WHO), United Nations Children’s Fund (UNICEF) and partners, there is a commitment to achieve the ambitious goals of The Global Vaccine Action Plan (GVAP) (6) in order to prevent millions of deaths by 2020. The success of national immunization programs throughout the twentieth century has contributed to the global eradication of small pox, elimination of polio virus in the United States, and a substantial reduction in the occurrence of vaccine preventable diseases (7).

Studies done in East Africa (6, 8) that analyzed data from Demographic Health Surveys (DHS) of the respective countries revealed that, vaccination varied significantly by country. In all countries, the majority of children received at least one dose of a WHO recommended vaccine; however in Ethiopia, Tanzania, and Uganda less than 50% of the children received a complete schedule of recommended vaccines.

BACKGROUND

Uganda

Uganda is a landlocked country in the Eastern part of Africa and lies astride the equator (9). It borders Kenya to the east, Tanzania to the south, Rwanda to the southwest, South Sudan to the north and Democratic Republic of Congo to the west. It spurns 241,039 square kilometers of surface area which has been subdivided into 112 administrative districts.

A British colony until 1962, Uganda has had political succession disputes which have ceased during the last two decades. With a population of about 35 million (10), Uganda has one of the fastest growing populations in the world with 48.1% below 14 years of age and an average total fertility rate of 6.9 children per woman.

The number of ethnic groups present in Uganda is very large, making it the most ethnically diverse country in Africa(11). The main ethnic group is called the Ganda tribe, which makes up 16.9% of the population, followed by Nkole, Soga and Kiga tribes, which make up 9.5%, 8.4% and 6.9% respectively. Apart from these, there are many other tribes, but they contribute a very small percentage of the total population (10).

The inhabitants of Uganda are mainly Christian. Roman Catholic, making up 47.9% of the total population, Anglican, Moslem and Pentecostal believers represent 35.9%, 12.1% and 4.5% of the total population respectively. This rich ethnic, cultural and religious diversity presumptively influences the uptake and perception to health care services (12).

Uganda's healthcare system (13) is decentralized with both public and private sectors playing a role in addition to faith-based and non-governmental organizations. At the national level, the functions of the Ministry of Health (MoH) include resource mobilization and budgeting, policy formulation and policy dialogue. These functions are then translated to districts through various representatives.

Immunization is a countrywide programme covering all districts of Uganda (14). The Ministry of Health/ Uganda National Expanded Programme on Immunization (UNEPI) is responsible for policy, standards and priority setting, capacity building, coordinating with other stakeholders and partners, resource mobilization, procurement of inputs such as vaccines and injection safety materials, monitoring and technical support supervision to the districts.

The districts and health sub-districts are responsible for planning, management and delivery of EPI (Expanded Programme on Immunization) services through the implementation of the overall district health plan. The community is involved in mobilization of parents to take their children for immunization. Immunization is part of the Primary Health Care (PHC) and is integrated into the child survival activities at the district and health facility levels.

Haemophilus Influenza and Hepatitis B were introduced to the former mandatory vaccines (BCG, Polio, DPT, and Measles) in 2002, as part of child survival strategy.

As part of the minimum health care package (MHCP), Uganda's Expanded Program on Immunization (14) in 2000 revitalised the role to boost immunization coverage following the previous declining trends. Issues among others included; poor access, low community involvement, poor cold chain maintenance and lack of logistics among others.

State of vaccination

Information from the Demographic and Health Survey (9, 15) indicates that only 4 in 10 children are fully vaccinated by 12 months in Uganda. This survey further revealed that children in the rural areas had a lower likelihood of being vaccinated compared to their counterparts in the urban areas, for both single and combined vaccinations. The 40% coverage is way below the current global coverage of 84% (4, 15) for Polio, Diphtheria-Pertussis-Tetanus (DPT) and Measles.

This survey (9) further revealed that vaccination coverage increases as the education attainment of a child's mother also increases and also if the mother comes from a richer household. In Eastern Uganda, over half of the population never completed primary education and hence, a need to investigate the association of education with completeness of immunization in this area.

It has further been documented (16, 17) that education of a mother and promotion of institutional delivery could help to maintain and enhance current immunization coverage. Complete adherence and compliance to the recommended four antenatal care visits (18) was equally a major predictor of complete immunization. Fewer number of children per family was a major predictor in complete immunization as presented in a study done in Kenya (19).

Recent WHO systematic reviews (20) and related publications (17, 21) have consistently highlighted the importance of a range of factors for immunization coverage such as; parental knowledge and attitudes, access, health staff attitudes and practices and beliefs. In these, some family demographic characteristics were strong underlying factors for complete vaccination, and hence forth the role to identify key questions for local study, inquiry and follow-up.

Under-5 mortality in Uganda remains significantly high at an alarming rate of 69 per 1,000 with an infant mortality rate of 45 per 1,000 (22). Prevention strategies to address the main childhood killer diseases focus on having all children fully vaccinated by the age of one year, hence the need to address barriers that hamper complete immunization.

This low coverage calls for periodic assessment of immunization rate and use of programs to improve immunization rate, knowledge and practice (8, 23). However this should be targeted and focused through ascertaining the differences in compliance in the different areas to reinforce implementation strategies. Vaccination is an important component of child survival strategy, not only against the dominant childhood illnesses but also creating a barrier to antibiotic resistance.

Studies have shown (24) the underlying decline in vaccination, however highlighting the need to explore societal factors in these settings where vaccination is low. This study will explore the emerging declining trends in vaccination coverage in Namayingo and Mayuge districts; pointing out the role of individual, social and health system factors that have an impact on vaccination coverage.

The growing evidence outlined before thus points to several areas and factors which affect immunization rates. These are 1) individual, 2) societal, 3) facility factors and 4) environmental factors. I constructed the conceptual framework below highlighting the factors that have been associated with complete vaccination coverage in different parts of the world.

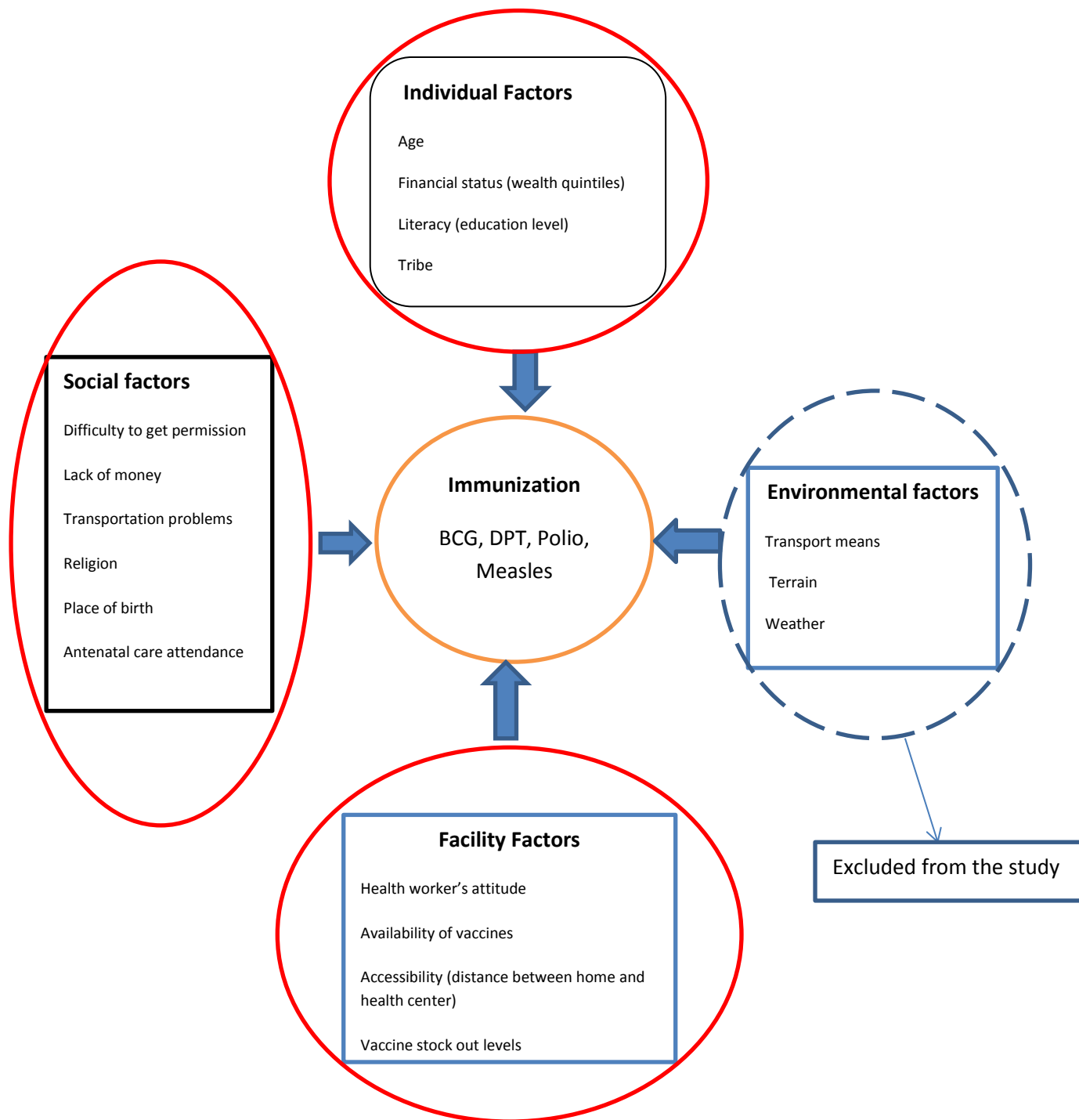


Figure 1. Conceptual framework

- Indicators included in the study
- - - . Indicators excluded from the study

Based on the above framework, my research question, aims and objectives were:

Research question

How do individual, societal and health system factors affect vaccination coverage (BCG, Polio, DPT and Measles) in children aged 12-23 months in Mayuge and Namayingo districts in Eastern Uganda?

Main Aim

To assess the effect of individual, social and health system factors on vaccination coverage of children aged 12-23 months in Eastern Uganda.

Specific Objectives

1. To determine the percentage of fully vaccinated and fully DPT vaccinated children aged 12-23 months in Namayingo and Mayuge Districts.
2. To assess the effect of individual, social and health system factors on the percentage of fully vaccinated children aged 12-23 months.

METHODOLOGY

Study design

This data analysis used data collected as part of the EQUIP (Expanded Quality Management Using Information Power) project carried out between 2010 and 2014 in Mayuge and Namayingo districts in Eastern Uganda. EQUIP was an interventional study that aimed at testing the effects and feasibility of a quality improvement approach to district, health facility and community level (25).

During the period of November 2011 to April 2014, continuous health facility and household survey collected data on health facility readiness, health output and outcome indicators to assess changes in one intervention and one non-randomly selected comparison district in Uganda. The household survey used a modular structure.

The household questionnaire included questions on household assets, housing type, ethnic group and geographical position (geographical information system data). A pregnancy history was recorded for all women of reproductive age (15 to 49 in Uganda) who lived in the selected households and who had had a baby since 2010. Women with a live birth in the two years prior to the survey were asked about care received during the antenatal, intra-partum and the post-partum period including vaccination status of their babies.

This study uses a sub-set of information from both the household survey and the health facility census (Annex 3). The household questionnaire including the interviews with women of reproductive age gave information on maternal age (asking the date of birth), education (asking for level of schooling completed), religion and assets and household characteristics to construct a poverty index as well as information on child immunization in the first year of life and uptake of antenatal care and delivery care.

The questioners addressed key barriers for women to access services since they are the main health care seekers for their children. In this, questions about their difficulty to get permission to seek care, capacity to obtain money and transport, health workers attitude and their preferences in seeking health care.

The health facility census gave information on;

Data collection

Selection of clusters, households, and respondents

Probability methods were applied to select 24 independent probability samples of 10 clusters from each district prior to the start of survey.

Village level population data were not available for Uganda, and only one of the two Ugandan districts had enumeration area population data, as districts were reformed in 2011. Therefore, clusters were drawn using a government generated parish level list that stated total number of households per parish (a parish represents a group of 4 to 10 villages). For each district, parishes were listed from north to south, the number of households within parishes cumulated, and parishes selected with probability proportional to the total number of households in the district.

Within each selected parish, villages were listed, allocated a random number, and the village with the lowest random number selected as the household cluster. Villages are relatively small in Uganda and all households were listed by the mapper with no segmentation, then 30 households systematically selected from the village list using a fixed fraction. Questionnaires were developed based on well-established sequences of questions as used in DHS.

Continuous survey teams

The survey team was trained and supervised. Data was entered using Personal Digital Assistants (PDA) where quality assurance mechanisms such as skips and ranges were inbuilt.(25).

Study setting

EQUIP was implemented in Eastern Uganda's Mayuge and Namayingo districts. Both districts have high maternal and newborn mortality rates and are predominantly rural with small district capitals (Annex 2). Mayuge district has a population of about 400,000, lies along the northern shores of Lake Victoria and includes six islands; however, the islands are not included in the intervention due to resource limitations. Namayingo District has a similar geography but only half the population of Mayuge.

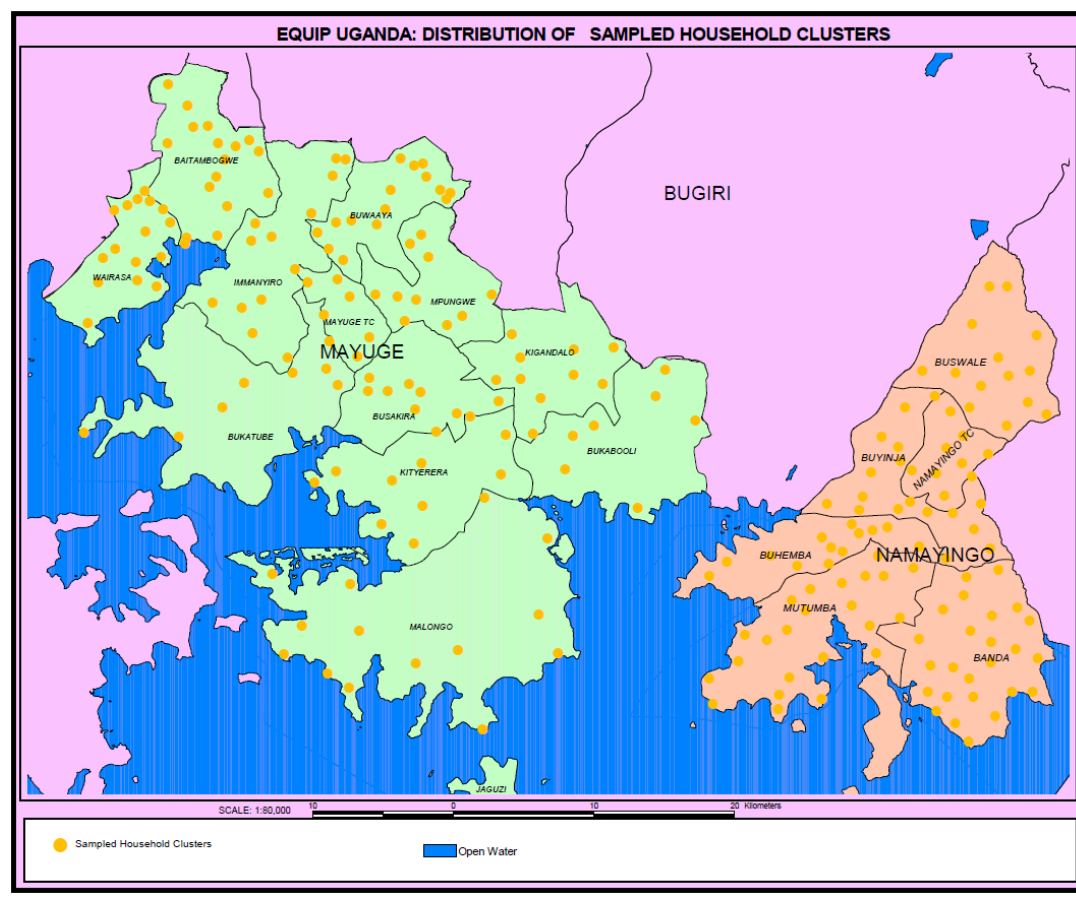
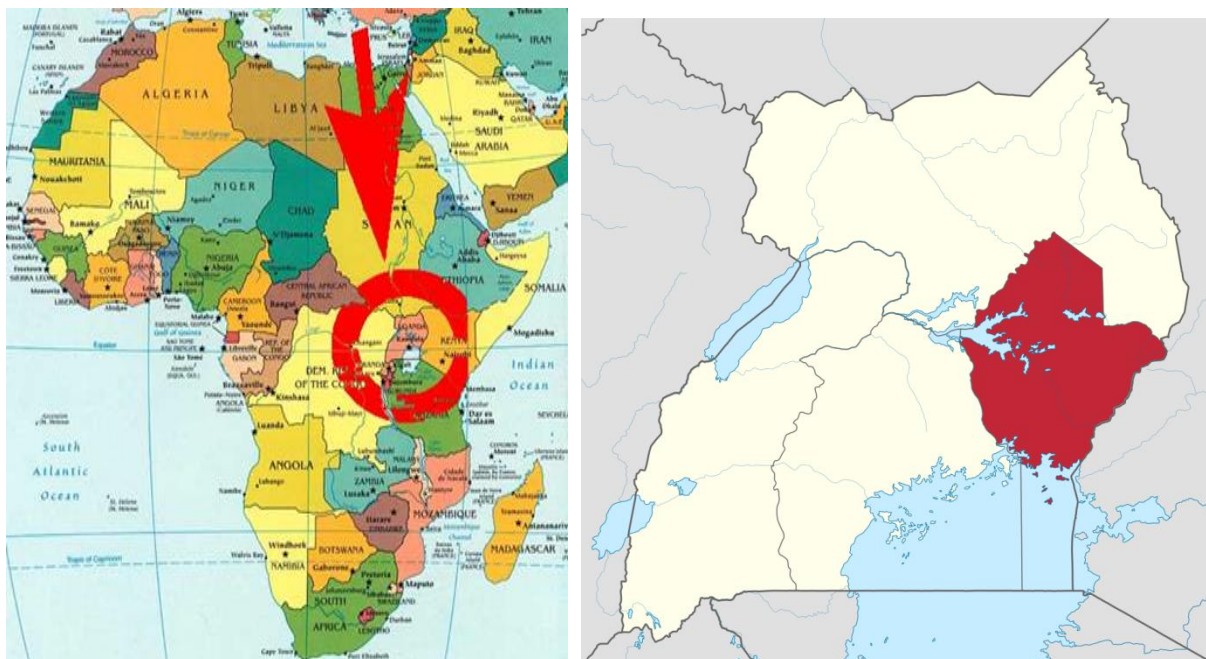


Figure 2a. Map of Africa illustrating the location of Uganda

Figure 2b. Map of Uganda showing study area

Figure 2c. Map of household clusters sample in Eastern Uganda

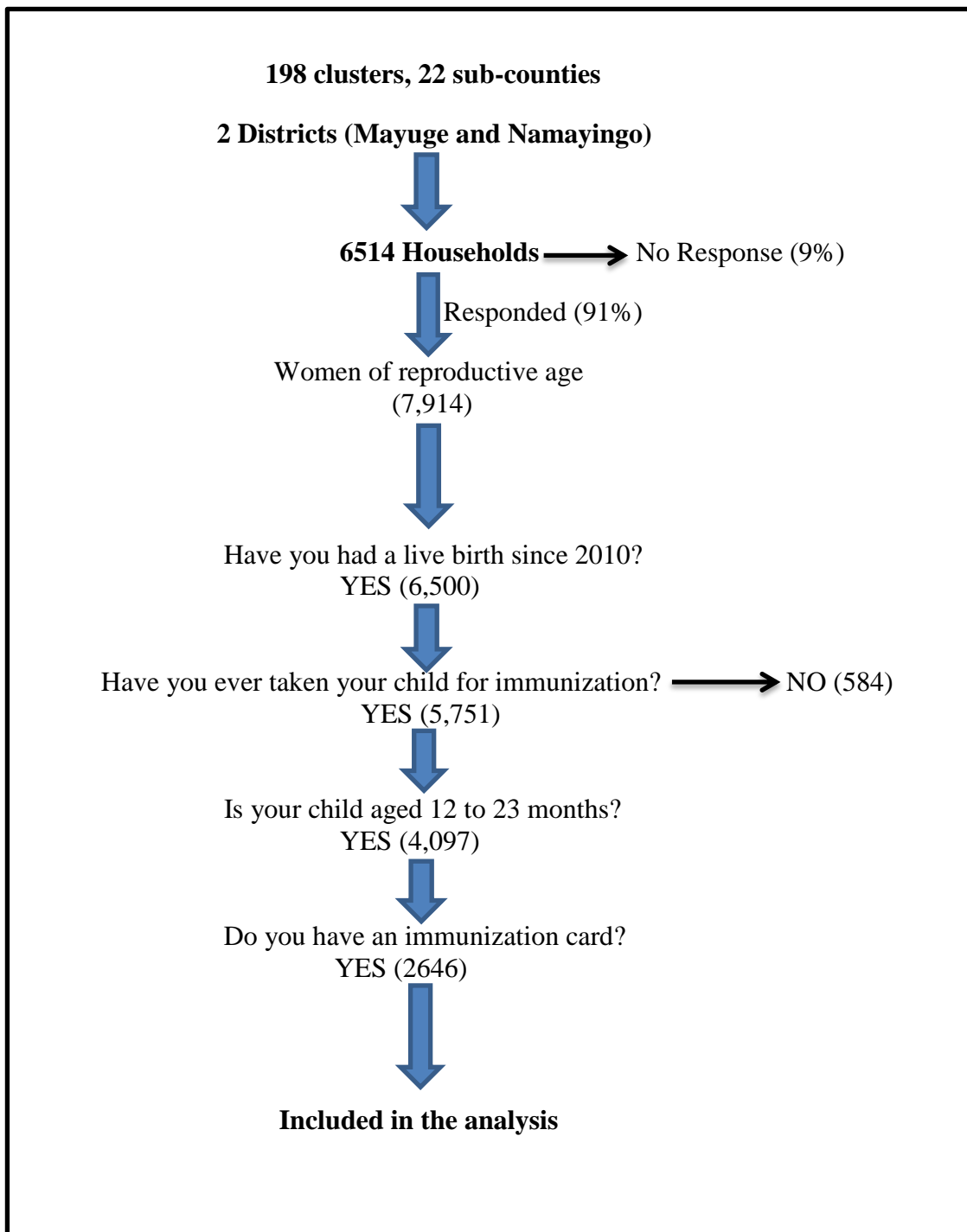


Figure 3. Flow chart of study participants

Ethical Clearance

Ethical clearance for the study was obtained from the local and institutional review boards such as the Makerere University School of Public Health and Uganda National Council of Science and Technology (Number HS 1085), and the London School of Hygiene and Tropical Medicine (LSHTM), ethical clearance No.5888. The study was introduced in the district through extensive community sensitization and meetings with sub-district authorities. For the household survey, written consent to participate is obtained from the household head and from women of reproductive age.

Data Management and Analysis

I used SPSS (Statistical Package for the Social Sciences) for data analysis. The modules consisting of; household characteristics, socio-demographics of the mother, perceptions of health services as well as dates of birth and information on care received ante-, intra-, and postpartum for live births, were merged by a unique household and women identifier.

Bivariate and multivariate analyses were conducted to identify independent predictors of immunization coverage. Odds and Adjusted Odds Ratio (OR & AOR) at 95% Confidence Interval (CI) were used to estimate the strength of association between independent variables and the dependent variable. The threshold for statistical significance was set at $p < 0.05$.

The main outcome measure of the study was the percentage of fully vaccinated children, i.e. those that had received; BCG, Polio 0, 1 and 2, DPT 1, 2 and 3 and Measles by the age of one year and were aged 12 to 23 months (26). Other measures included the, proportion of children who had received complete DPT and complete polio vaccinations.

The main outcome measure (percentage of fully vaccinated children) was stratified for complete DPT Vaccination (received DPT 1, 2 and 3). This is because DPT requires all the three different doses to be fully effective and because it protects against three different pathogens. The vaccine requires three doses to subsequently boost the immunity to a level sufficient to provide long term protection. This was however not done for complete Polio vaccination since it is a single pathogen vaccine. The respective indicators were analyzed for complete DPT vaccination as well in order to ascertain whether there is a difference in the predictive models for complete immunization coverage.

RESULTS

General Characteristics of study participants

The study identified 6154 households in the 2 districts. In 9% households, no one was present or the head of the household refused participation. In the 91% participant households, we identified 7,914 women of reproductive age of whom 6,500 agreed to be interviewed.

The average age of 6,500 women interviewed was 28 years, and an interquartile range 10.66 years. Of these, 60.7% were Christians, 24.4% Moslems and only 2% belonged to other religious groups. 81.2% had incomplete primary education, 16.7% had completed primary education, 1% secondary education and 1% had completed tertiary education. Of these, 16.7% lived within a distance of 1km from the nearest health Centre, 49.9% lived within 1-3 km and 18.7% lived within more than 3 km from the nearest health center.

Children's Vaccination status

Figure 4 illustrates immunization coverage in the districts in the first year of life among children between 12 to 23 months. Out of the 2646 mothers whose children were between 12 and 24 months that were interviewed, 2,575 (97.1%) had their children vaccinated with BCG vaccine by the age of one year. A total of 1,323 (49.9%) had received Polio 0 vaccine at birth or within the first 4 weeks of life and 2,426 (91.5%) had received Polio 1 and 2,165(81.8%) had received the Polio 2 in the first year of life.

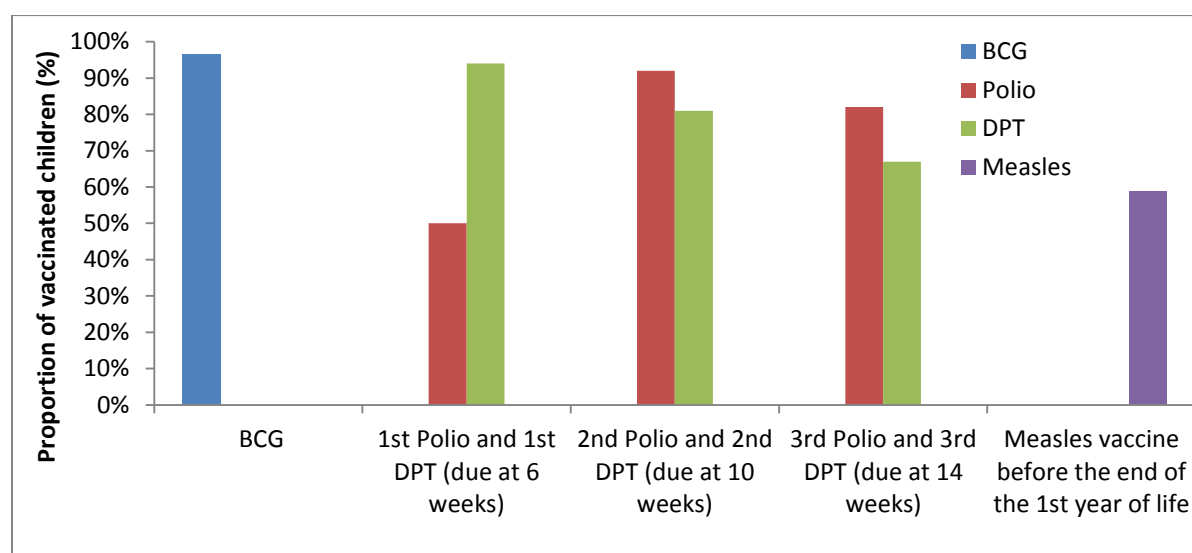


Figure 4. Vaccination coverage during the first year of life among 12-23 months old children in Eastern Uganda

Similarly, 2,475 (93.5%) had received the first DPT vaccine, 2,149 (81.2%) had received DPT 2 and 1,777 (67.1%) had received the DPT 3 vaccine at one year of life. Only 1,554 (58.7%) had received their Measles vaccine in the first year of life.

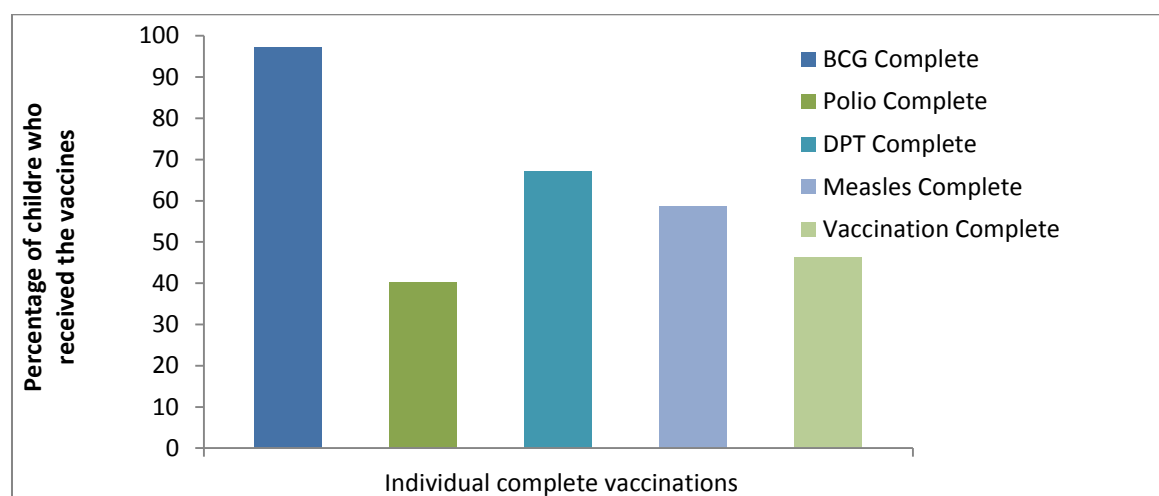


Figure 5. Distribution of complete vaccination

Figure 5 illustrates the percentage of complete vaccinations in children aged 12-23 months. 2,575 (97.1%) had a complete BCG vaccination, 1,064(40.2%) had completed Polio vaccination, 1,749(67%) had completed DPT, 1,554 (58.7%) had completed Measles and 981(17.1%) had completed their immunization schedule by one year. Complete immunization among the different sub-counties was distributed as below:

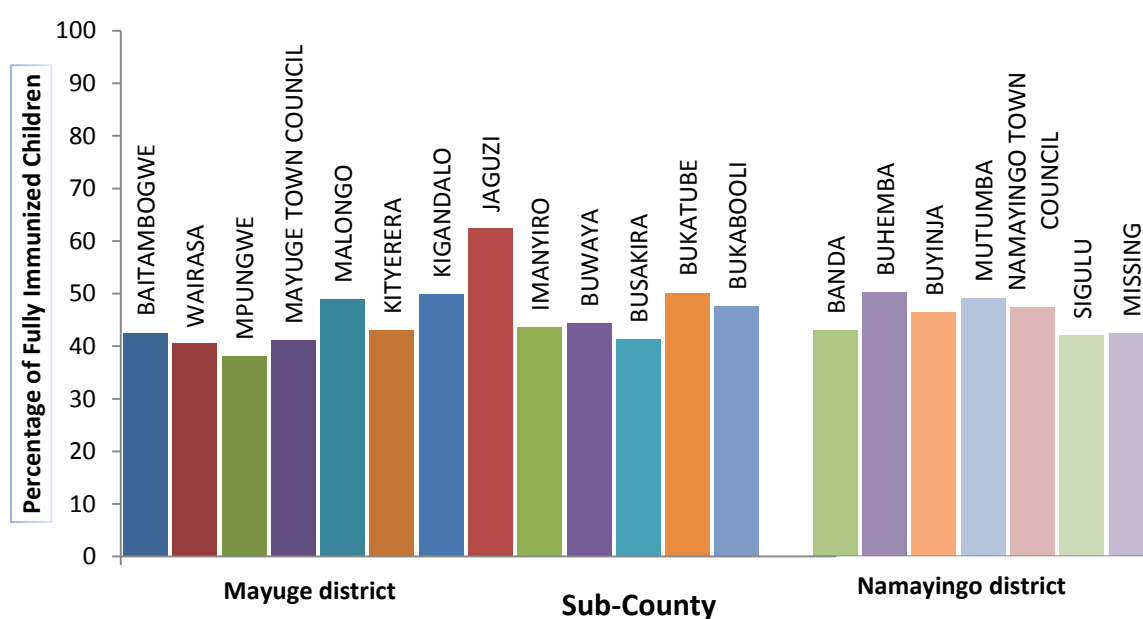


Figure 6. Distribution of complete immunization by sub-county among children aged 12-23 months in Eastern Uganda

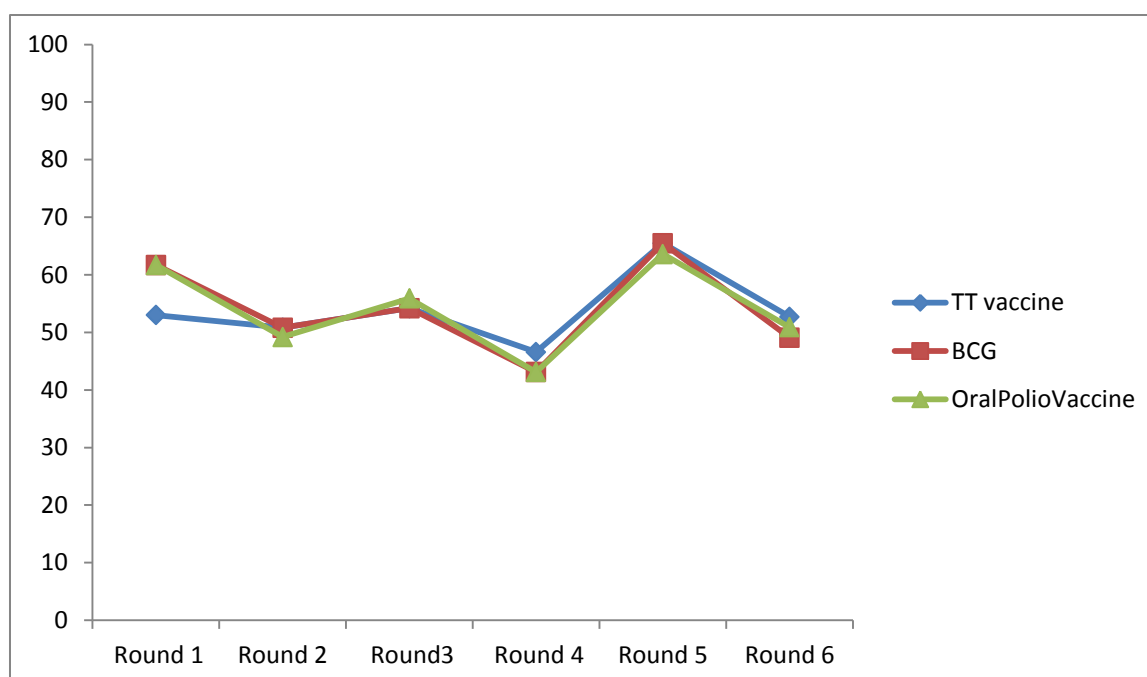


Figure 7. Percentage vaccine availability over the respective study rounds

Figure 7 illustrates the availability of vaccines over the study rounds. Average vaccine availability was always below 70% for each of the respective vaccines that were assessed in this study.

Determinants of vaccination coverage

Table 1. Determinants of complete vaccination and complete DPT vaccination

Exposure variables & category	Total (6513)	N (%)		Complete DPT(yes)	P value for DPT
		Complete vaccination (yes)	P Value for all		
<u>Individual factors</u>					
Mother's age group			0.000		0.175
<20	692	276(39.9)		169(61.2)	
20-30	2872	1316(45.8)		883(67.0)	
>30	2121	1037(48.9)		688(66.4)	
Valid total and percentage	5685	2629(46.2)		1740(66.2)	
Mother's level of education			0.397		0.994
Primary incomplete	4653	2126(45.7)		1405(66.1)	
Primary	954	464(48.6)		306(65.9)	
Secondary	57	28(49.1)		19(67.9)	
Tertiary	60	28(46.7)		18(64.3)	
Valid total and percentage	5724	2646(46.2)		1748(66.1)	
Asset-based wealth quintiles			0.149		0.004
Lowest	1208	583(48.3)		359(61.6)	
Second	1374	660(48.0)		435(65.9)	
Middle	953	426(44.7)		270(63.4)	
Fourth	1127	499(44.3)		345(69.3)	
Highest	1017	461(45.3)		331(71.6)	
Valid total and percentage	5679	2629(46.3)		1740(66.2)	

Ethnic group(tribe)			0.417		0.069
Musoga	1411	631(44.7)		428(67.8)	
Musamya	1387	651(46.9)		447(68.7)	
Other	2928	1365(46.6)		874(64.0)	
Valid total and percentage	5726	2647(46.2)		1749(66.1)	
<u>Social factors</u>					
Religion			0.094		0.037
Christian	3563	1657(46.5)		1125(67.9)	
Moslem	1380	611(44.3)		395(64.6)	
Other	12	3(25.0)		2(66.7)	
Valid total and percentage	5726	2647(46.2)		1749(66.1)	
Place of birth			0.026		0.000
No health Facility	3497	1628(47.5)		1009(62.0)	
Health Facility	2199	985(44.8)		712(72.2)	
Valid total and percentage	5628	2613(46.4)		1721(65.9)	
Antenatal care attendance			0.199		0.000
No	253	124(49.0)		62(50.0)	
Yes	5449	2512(46.1)		1680(66.9)	
Valid total and percentage	5702	2636(46.2)		1742(66.1)	
Mothers report difficulty to get permission from their husbands			0.071		0.142
Yes	22	8(36.4)		7(50.0)	
No	4921	2670(54.4)		1511(67.1)	
Valid total and percentage	4946	2678(54.2)		1518(67.0)	
Mothers report transport problems			0.145		0.293
Yes	863	410(47.5)		280(68.3)	
No	4080	1855(45.5)		1238(66.7)	
Valid total and percentage	4943	2265(45.8)		1518(67.0)	
Mothers report money problems			0.114		0.078
Yes	2432	1136(46.7)		745(65.6)	
No	2511	1129(45.0)		773(68.5)	
Valid total and percentage	4943	2265(45.8)		1518(67.0)	
Mothers prefer traditional treatment			0.622		0.449
Yes	4	2(50.0)		2(100)	
No	4939	2263(45.8)		1516(67.0)	
Valid total and percentage	4943	2265(45.8)		1518(67.0)	
<u>Health System Factors</u>					
Distance of household to nearest health center			0.335		0.000
<1 km	995	469(47.1)		333(71.0)	
1-3 km	2895	1317(45.5)		895(68.0)	
3-5 km	735	323(43.9)		209(64.7)	
>5 km	327	161(49.2)		84(52.2)	
Valid total and percentage	4952	2270(45.8)		1521(67.0)	
Mothers reported good attitude of health workers			0.071		0.343
Yes	373	185(49.6)		127(68.6)	
No	4570	2080(45.5)		1391(66.9)	
Valid total and percentage	4943	2265(45.8)		1518(67.0)	
Vaccine stock-out levels			0.032		0.046
Low	1523	676(44.4)		459(67.9)	
High	3508	1658(47.3)		1063(64.2)	
Valid total and percentage	5031	2334(46.4)		1522(65.2)	

Complete DPT-Number of children between 12 and 24 months that received DPT 1, DPT 2 and DPT 3

Regression Analysis

Out of the 14 variables in the bivariate analysis, 10 had an association at 20% significance level and were included in the multivariable logistic regression model. Those were: maternal age, wealth quintiles, religion, place of birth, attendance of antenatal care, ethnic group, difficulty of mothers to get permission from their husbands, good attitude of health workers, mothers' preference for traditional treatment, mothers reporting of money problems and vaccine stock out levels.

Table 2. Binary logistic regression results for factors affecting complete immunization, adjusted for clustering.

Variable	Crude	OR (95% C.I)		
		P value	Adjusted	P value
Mother's age group				
<20	Ref			
20-30	0.78(0.7-0.9)	0.005		
>30	0.69(0.6-0.8)	0.000		
Wealth Quintiles				
Lowest	Ref		Ref	
Second	1.01(0.9-1.2)	0.908	1.02(0.9-1.2)	0.808
Middle	1.15(1.0-1.4)	0.100	1.16(1.0-1.4)	0.089
Fourth	1.17(1.0-1.4)	0.054	1.16(1.0-1.4)	0.070
Highest	1.13(1.0-1.3)	0.167	1.14(1.0-1.4)	0.138
Religion				
Christian	0.38(0.1-1.1)	0.151		
Moslem	0.35(0.1-1.3)	0.118		
Other	Ref			
Place of birth				
Other	Ref		Ref	
Health facility	1.11(1.0-1.2)	0.049	1.10(1.0-1.2)	0.101
Antenatal care attendance				
No	Ref			
Yes	1.12(0.9-1.2)	0.364		
Ethnic group(tribe)				
Others	Ref			
Musamya	1.08(1.0-1.2)	0.240		
Musoga	0.99(0.9-1.1)	0.845		
Mothers report difficulty to get permission from their husbands				
Yes	Ref			
No	0.48(0.2-1.2)	0.100		
Mothers report money problems				
Yes	Ref			
No	0.93(0.8-1.0)	0.217		
Mothers reported good attitude of Health workers				
No	Ref			
Yes	0.85(0.7-1.0)	0.128		
Vaccine stock out levels				
High	Ref			
Low	0.89(0.8-1.0)	0.060		

In the regression model for complete vaccination, neither of the social, individual nor health system factors was significantly associated with complete immunization at the p value < 0.05 level.

Table 3. Binary logistic regression results for factors affecting complete DPT immunization, adjusted for clustering.

immunization, adjusted for clustering.				
Variable	Crude	OR(95% C.I)		
		P Value	Adjusted	P value
Mother's age group *				
<20	Ref		Ref	
20-30	1.29(1.0-1.7)	0.064	1.42(1.1-1.9)	0.020
>30	1.25(1.0-1.7)	0.109	1.40(1.0-1.9)	0.028
Religion				
Christian	1.05(0.1-11.7)	0.964		
Moslem	0.94(0.1-10.1)	0.942		
Other	Ref			
Antenatal care attendance*				
No	Ref		Ref	
Yes	2.02(1.4-2.9)	0.000	1.70(1.1-2.5)	0.010
Place of Birth*				
Other	Ref		Ref	
Health Facility	1.59(1.3-1.9)	0.000	1.52(1.3-1.8)	0.000
Mothers report money problems				
Yes	Ref			
No	0.88(0.7-1.1)	0.144		
Ethnic Group(tribe)				
Others	Ref			
Musamya	1.18(1.0-1.5)	0.098		
Musoga	1.23(1.0-1.5)	0.041		
Distance of household to nearest health center*				
<1 km	2.24(1.5-3.2)	0.000	2.09(1.4-3.0)	0.000
1-3 km	1.94(1.3-2.7)	0.000	1.90(1.4-2.7)	0.000
3-5 km	1.14(1.1-2.5)	0.008	1.60(1.1-2.5)	0.018
>5 km	Ref		Ref	
Vaccine stock out levels				
High	Ref			
Low	0.85(0.7-1.0)	0.085		

*Factors which are significant in the multivariate logistic regression model, hence positive predictors of complete DPT vaccination in Eastern Uganda.

Out of the 14 variables in the bivariate analysis, 8 had an association with complete DPT vaccination i.e., those with a p value <0.2 and were included in the logistic regression model. Of these, 5 were significant in the logistic regression model for complete DPT vaccination at the p value <0.05 level.

The coefficient maternal age is positive and significant at the p value <0.05 level. Children with older mothers (between 20-30 years) had 40% higher odds of receiving complete DPT vaccination. Children born to mothers above 30 years had 1.4 higher odds of receiving full DPT vaccination in the first year of life compared to those born to mothers below 20 years.

The coefficient antenatal care attendance was positive and significant at the p value <0.05 level. Children with mothers who attended antenatal care had 1.7 higher odds of receiving complete DPT vaccination by the age of one year compared to those with mothers who had not attended antenatal care. The coefficient place of birth is also positive and significant at the p value <0.05 level. Children born in a health facility had 1.5 higher odds of receiving full DPT vaccination by the age of one year compared to those that are not delivered at a health care facility.

The coefficient distance of household from the nearest health center was positive and significant at the p value <0.05 level. Children whose mothers stay in a distance within one kilometer from the health center had more than 2 times higher odds of receiving full DPT vaccination compared to those that live within a distance above 5 kilometers.

Children whose mothers stay at a distance between 1 and 3 kilometer from the health center still had almost 2-fold higher odds of receiving full DPT vaccination compared to those that live in a distance above 5 kilometers. Children whose mothers stay at a distance within 3 and 5 kilometer from the health center had 1.6 increased odds of receiving full DPT vaccination compared to those that live in a distance above 5 kilometers.

DISCUSSION

This study describes immunization coverage and associated predictors for children between 12 and 24 months in Eastern Uganda. In Eastern Uganda, full vaccination coverage including BCG, DPT, Polio and Measles was 46%. This was clearly much lower than the reported global figure of 84% and lower than the reported average as well in Uganda (52%) (9), according to the most recent demographic survey. There is a clear declining trend from reception of the first BCG vaccination at birth to that of Measles by nine months. Complete vaccination was generally low across all sub-counties as well, ranging from 38% in Mpungwe to 62% in Jaguzi with no substantial difference between the study districts.

From the exploratory analysis, it was clear that complete immunization was not significantly associated with any individual, social and health system factors except health facility delivery that were analyzed in the study. This was in agreement with earlier studies (8) done in East Africa where social-demographic covariates were not consistently associated with complete vaccination status, suggesting that other factors are more important to explain low immunization coverage.

For complete DPT vaccination however, unadjusted and adjusted analysis confirmed that vaccination completeness was positively associated with maternal-age above 20 years, health facility delivery, attendance of antenatal care and mothers' residence closer to the health facilities. This is in agreement with previous African studies that have highlighted increasing maternal age (27, 28) and health facility delivery (8, 27-29) as positive predictors of vaccination completeness.

Attendance of antenatal care was associated with higher compliance like in previous studies (18), however, attendance of antenatal care and health facility delivery had a significant statistical correlation, hence could be an effect modifier in this study.

The low vaccination coverage for DPT, Polio and Measles across all socio-demographic, economic and health system factors raises the question about what is needed to improve vaccination coverage. This is evidence that interventions in health system improvement will have a positive impact on immunization coverage (30) through an integrated approach of health care utilization and coverage.

Probable solutions might be to strengthen information on vaccination at all contact opportunities along the continuum of care. Antenatal care is usually the first contact of the

women with the health care system and its utilization through dissemination of vaccination information could serve a purpose in improving vaccination coverage. Studies in this region have highlighted the need to address multiple health challenges for the people in order to have pronounced effect of health interventions (31) due to the enormous burden of diseases and health challenges in Eastern Uganda. Results showed that at least half of the mothers delivered outside the health facility and therefore there is a need to identify children born outside these facilities to be taken for immunization.

Increasing level of education has been highlighted in previous studies as (32-34) as a positive predictor of complete immunization. In this context however, it was not significantly associated to complete immunization. This could be explained by the fact that the majority of the women that dominated the study in this region never completed primary education. It is also possible however that the non-respondents or those that were not found at home could be the women with higher education.

Although vaccine stock out levels was not associated with complete vaccination, it was noted that there was one or more vaccines out of stock at every round of the study across all sub-counties. This highlights the role of the health care system to avail essential vaccines and provide information on availability and accessibility.

Uganda's expanded program on immunization set up goals to scale up vaccination that included; timely procurement and storage, supply chain management, recruitment of workers and logistics supply (14). Since 2010, this program has faced challenges including a weak vaccine stock control system, minimal involvement of the private sector, and low utilization of data. All these challenges and others rely on funding mechanisms for the different health programs, which is a key in a functional health system (35). Uganda's immunization program has entirely relied on donations that have been inconsistent because of changes in the political climate from donor agencies (36).

Distance of household from nearest health center was significantly associated with complete DPT immunization. This highlights the importance of accessibility in uptake of vaccination services. This is however difficult to generalize because the study was unable to determine whether the nearest health facility was the place where the children received the respective immunization. Results of this study could be generalizable across different rural areas in Uganda where social-demographic characteristics and disease patterns are similar. This however should be able to contextualize the study limitations as shown below.

Strengths and Limitations of the study

The study included a large number of women of reproductive age and that is why it had adequate power to detect small differences in vaccination rates between different groups. This high response rate of 90% minimized the potential for selection bias.

There was a potential of recall bias that posed a limitation to the study. This is because the respondents answered the questions much later after the intended outcome. Accuracy of reported maternal perceptions of the health system could not be ascertained.

Recall biases were however minimized for the major outcome indicator that relied on the information that was on the child's immunization card. However, this excluded women who did not have a vaccination card. This might have biased the result to levels lower than true levels as women who had never gone for any vaccination event, and thus those that did not possess a vaccination card were likely to have lower vaccination levels.

However, the reliance on information extracted from vaccination cards is superior to women's recall as it can be difficult to remember over a long period, how and which vaccinations were administered. However, we cannot exclude that children actually received vaccination although the cards were not filled in. This possibly lowered the number of reported completely immunized children.

Paternal factors were not available which would equally have been crucial in this study and neither were annual weather patterns to explain seasonal variations. The study was not able to highlight possible side effects of vaccination or highlight possible illnesses(17) that the children might have faced that coincided with their vaccination schedule and program hence missing out on the immunization.

Conclusions and Recommendations

With an average complete vaccination in both districts at 46%, immunization compliance remains significantly low in Eastern Uganda. Full vaccination rates were low in all sub-groups. The results suggest that increasing maternal age, attendance of antenatal care, delivery from a health facility and shorter distance from the health center are significantly associated with complete DPT immunization in the first year of life in Eastern Uganda however absolute differences were limited.

The influence of institutional delivery calls for advocacy to encourage women to seek healthcare especially during their antenatal and perinatal period. Despite the different social barriers to healthcare access for both women and their children, these were not significantly associated with complete immunization and efforts to improve vaccination coverage rely on health system strengthening.

With more than 50% of the children dropping out by the end of the first year of life, there is a need for continuous evaluation and review of the role of reminders to keep mothers updated on the immunization schedules. There is a need to review the health care system barriers through qualitative research and maternal perceptions through focused group discussions. Systematic reviews have highlighted the use of immunization information systems to improve immunization coverage. In this, the health system would be able to create or support effective interventions such as reminders and recall, inform missed vaccination opportunities and facilitate vaccine management and accountability (37).

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ANNEX

1. Uganda Immunization Schedule (14)

Vaccine/ Antigen	Dosage	Doses Required	Minimum Interval Between Doses	Minimum Age to Start	Mode of Administration	Site of Administration
BCG	0.05ml up to 11 months, 0.10ml after 11 months	1	None	At birth (or first contact)	Intra-dermal	Right Upper Arm
DPT- HepB+Hi b	0.5 ml	3	One month (4 weeks)	At 6 weeks (or first contact after that age)	Intra-muscularly	Outer Upper Aspect of Left Thigh
Polio	2 drops	0+3	One month (4 weeks)	At birth or within the first 2 weeks (Polio 0) and six weeks or first contact after 6 weeks (Polio 1)	Orally	Mouth
Measles	0.5 ml	1	None	At 9 months (or first contact after that age)	Sub-cutaneously	Left Upper Arm
Tetanus Toxoid	0.5 ml	5	TT1 & TT2; 4 weeks TT2 & TT3; Six months TT3 & TT4; One year TT4 & TT5; One year	At first contact with a pregnant woman or women of child bearing age (15- 45 years)	Intra-muscularly	Upper Arm

2. Study districts' characteristics

Indicator	Namayingo District	Mayuge District
Population	233,000 (38)	412,500
Administrative structure	2 health sub-districts, 270 villages	3 health sub-districts, 13 sub- counties 488 villages
Health facilities	22 (no hospital)	41+1 hospital
Maternal mortality ratio	438 (national, 7 years prior to survey)	
Newborn mortality rate		23 (2001–2011, East Central) (9)
Infant mortality rate		61 (2001–2011, East Central) (9)
< 5 mortality rate		< 5 mortality rate
Total fertility rate		6.8 (rural Uganda)
HIV prevalence		5.9% (East Central) (9)

3. Household Questionnaire

H1	District: <i>(PDA drop down list)</i>	<input type="text"/>
H3	UG: Sub county <i>(PDA drop down list)</i>	<input type="text"/>
H4	UG:EA identifier <i>(PDA drop down list)</i>	<input type="text"/>
H5	Cluster no	<input type="text"/>
GPSX	X GPS Coordinates	<input type="text"/>
GPSY	Y GPS Coordinates	<input type="text"/>
H6	Household no	<input type="text"/>
H7	Unique household ID <i>(generated by PDA)</i>	<input type="text"/>
H8	Interviewer initials	<input type="text"/>
H9	Date <i>(dd/mm/yyyy, PDA format)</i> <i>Enaku dhomwezi</i>	<input type="text"/>
H10	Name of household head <i>Erina ely'omukulu wamaka</i>	<input type="text"/>

H11	Have you read him/her the consent form? yes (2) no-one is available <i>Omusomeire Embaluwa esaba olukusa?</i> <i>(1)Yii (2)Mbe</i>	<input type="text"/>
H12	Does the respondent agree? <i>(1)Yes (2) No IF NO END INTERVIEW HERE</i> <i>Aikiriiza? 1)Yii (2)Mbe OBANG BBE, LEKERAGHO OKUBUZZA</i>	<input type="text"/>
H13	Who is the respondent? <i>Household head (2)Representative</i> <i>Nani Aizemu?</i> <i>(1) Omukulu wamaka (2) Amukikirire</i>	<input type="text"/>
H13a	What is the ethnic group of the household head? <i>Omukulu wamaka waiwanga ki?</i> <i>(1)Musoga (2)Musamya (3)Muganda (4)Munyole</i> <i>(5)Mudaama (6)Muteso (7)Mugwere (8)Musiki</i> <i>(9)Mugishu (10)Other</i>	<input type="text"/>
H13b	If Other ethnic group, Specify:..... <i>Ekindhi, Inhonholah.....</i>	<input type="text"/>
H13c	How many people live in this household? <i>Munumba enho mulimu abantu bameka?</i>	<input type="text"/>

H14. Household listing

Please can I ask the names of all the people in your household? *Start with the head of household and older people*
(Nkusaba ompeku amaina agabantu bona bona abomunhumba yo. Tandika nomukulu owaamaka nabantu abakulu.

Number of the person	Name of the person	Sex (1)M (2)F	Date of birth (dd/mm/yyyy) y; don't know date	Complete level of education (enter level completed) <i>1) Primary</i> <i>2)Secondary</i> <i>3)Tertiary</i>	What is the ethnicity/tribe of this member? <i>Gha lwanga ki?</i>	Other ethnicity, Specify.....	Religion (1)Christian (2)Muslim (3) Other
<i>Namba ey'omuntu</i>	<i>Erina ely'omuntu</i>	<i>Ekikulakye</i>	<i>Enaku edobuzaale 01/01/2099)</i>	<i>Eby'obwegerese (Ghandika gheyakanga)</i>	<i>(1)Musoga (2)Musamya (3)Muganda (4)Munyole (5)Mudaama (6)Muteso (7)Mugwere (8)Musiki (9)Mugishu (10)Other</i>	<i>Lwanga elindhi, Inhonholah.....</i>	<i>Iddinii ki? (1)Christian (2)Muslim (3) Other</i>
				<i>1) Primary</i> <i>2)Secondary</i> <i>3)Tertiary</i>			
H14A	H14B	H14C	H14D	H14I	H14M	H14N	H14J

Now I want to ask you some questions about the characteristics of your household
Buti nhenda okubuzaku obubuzo ku neebisa eyamakaago.

H15	Do you rent this house? (1) yes (2) no (3) other <i>Opangisa enhumba eno?(1)Yii (2)Mbe (3)Other</i>	<input type="checkbox"/>
H16	What kind of toilet facilities does your household have? (1) Flush toilet (2) Pit toilet/ltrine (3) No facility/bush/field <i>Amakaago galina mugwana kika ki?</i> (1) <i>toyi yamadhi</i> (2) <i>toy eyekiina</i> (3) <i>wazira mugwana/nsiko/kibangilizi</i>	<input type="checkbox"/>
H17	What is the main source of drinking water for members of your household? (1)Piped water into dwelling; (2)Piped water into compound; (3)Public tap; (4)Borehole; (5)Dug well; (6)Water from spring; (7)Tanker truck; (8)Surface water (river/dam/lake ect); (9)Bottled water; (10)other <i>Amaadhi ag'okunwa mumaka muno musinga kugatolagha?</i> (1) <i>Amaadhi ga paipu munhumba</i> (2) <i>Amaadhi ga paipu mu luuya</i> (3) <i>Tapu ya buli muntu</i> (4) <i>enaikonto</i> (5) <i>Nsulo nsime</i> (6) <i>Maadhi ga mufuredhe</i> (7) <i>Maadhi gamukitanka kya motoka</i> (8) <i>Amaadhi agalegama</i> (9) <i>maadhi gamukyupa</i> (10) <i>ekyind</i>	<input type="checkbox"/>
H18	What type of fuel does your household mainly use for cooking (select only one) (1)Electricity; (2)Gas; (3)Kerosene; (4)Charcoal; (5)Firewood/straw; (6)Dung; (7)Other <i>Mumaka gano musinga kufumbisa kyi?</i> <i>Londaku kirala</i> (1) <i>masanhalaze</i> (2) <i>Gaasi</i> (3) <i>Mafuta</i> (4) <i>manda</i> (5) <i>Nku/bukuta</i> (6) <i>Busa</i> (7) <i>ekyindhi</i>	<input type="checkbox"/>
H19	What is the main floor material? (1)Natural floor (earth/sand/dung) (2)Rudimentary floor (wood/palm/bamboo) (3)Finished floor (Polished wood, vinyl, tiles, cement, carpet) <i>Ghansi munhumba yo osinga wakoze sawo ki?</i> (1) <i>Tiwakole (Itaka/mukyanga/bus)</i> (2) <i>Bakolagho na mbaagho, misansa, mibanda</i> (3) <i>Yamala okolebwa (embaagho enhirize, amategula ag'awansi, sumiti, kapeti)</i>	<input type="checkbox"/>
	In this household is there anyone who owns	(1)Yes(Yii) (2)No(Mbe)
H20	Fridge <i>Filigi</i>	<input type="checkbox"/>
H21	TV <i>Telefaina</i>	<input type="checkbox"/>
H22	Radio <i>Radiyo</i>	<input type="checkbox"/>
H23	Bicycle <i>Akagaali</i>	<input type="checkbox"/>
H24	Mobile phone <i>Eisimu ely'omungalo</i>	<input type="checkbox"/>

H25	In this house are there ducks or chickens? How many? (write the number; 999 if respondent does not know) _formatted as <u>1</u> (yes) <u>2</u> (no) <i>Mu maka gano mulimu embati oba enkoko?e</i>	<input type="checkbox"/>
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H25a	_ How many ducks or chickens? <i>Mulimu embati oba enkoko Imeka?</i>	
H26	Do you have animals in this household like goat, sheep or cattle-how many? (write the number; 999 if respondent does not know). _1 (yes) 2 (no) SKIP TO H27 <i>Mulina ebisolo mumaka gano nga embuzi, entama, oba ente?</i>	<input type="checkbox"/>
H26a	How many animals? <i>Mulina ebisolo bimeka?</i>	<input type="checkbox"/>
H27	Is the house connected to electricity yes (2)no <i>Enhumba elimu amasanharaze (1) Yii (2) Mbe</i>	<input type="checkbox"/>
H28	What is the main material of the roof: Iron sheets or tiles; (2) Thatch/grass or leaves; (3) Other <i>Enhumba yasinga kuserekebwa naki</i> (1) <i>mabati oba mategula</i> (2) <i>Isubi/oba makoola</i> (3) <i>ekyindi</i>	<input type="checkbox"/>
H29	How many mosquito nets does your household have? (Count those in use plus those not in use, write total number) <i>Amakaago galina obutimba obwensiri bumeka?</i> If "0" SKIP TO W1	<input type="checkbox"/>

M97	Have you ever taken '[NAME]' for a vaccination? PROBE – HEALTH FACILITY OR VACCINATION DAY (1)yes (2)no – GO TO MODULE 4 <i>Watwalaku (NAME) okumugema?</i>	<input type="checkbox"/>
M98	If yes: Do you have any record/card where [NAME] vaccinations are written down? (1)yes (2)no <i>Oba Yii: Olina kadi webaghandika okugema kwa (NAME) (1)Yii (2)mbe</i>	<input type="checkbox"/>

	Has [NAME] received the following vaccinations? (NAME) bamugemesa bino wamanga?	
M99	BCG	<input type="checkbox"/>
M100	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M101	Polio 0 (Polio given at birth and given in the mouth (oral))	<input type="checkbox"/>
M102	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M109	Polio 1	<input type="checkbox"/>
M104	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M105	Polio 2	<input type="checkbox"/>
M106	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M107	DPT 1	<input type="checkbox"/>
M108	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M109	DPT 2	<input type="checkbox"/>
M110	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M111	DPT 3	<input type="checkbox"/>
M112	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M113	Measles or MMR	<input type="checkbox"/>
M114	Oba yyi, li? If yes: When? record date given, or 01/01/2009 if date not available	<input type="checkbox"/>
M115	Vitamin A	<input type="checkbox"/>
M116	Oba yyi, li? If yes: When? record date last dose given, or 01/01/2009 if date not available	<input type="checkbox"/>

MODULE 4 USER PERCEIVED QUALITY

ALL WOMEN 13-49

Now I want to talk to you about your experience of health care for yourself or your child in the past 12 months.

Buti nnenda okwogeraku niwe kungeri gyobona eby'obwiidhandhabi kubulamu bwo oba obw'omwaanawo mu myezi 12 egibise?

Q1	Would you say that you have problems to access health care for yourself or your child? (1)yes (2)no skip to Q8 Oyinza okoba oti olina obuzibu mukufuna obwiidhandhabi obubwo oba obw'omwaanawo? (1)yii (2)Mbe skip to Q8	<input type="checkbox"/>
	If yes What type of problem do you have? Buzibu ki bwolina? Do not read the list, select all that are mentioned, probe – anything else?	(1)Yes(Yii) (2)No(Mbe)
Q3	Not enough money for services at the facility (inc drugs) Sente tedhimala kufuna bwidhandhabi nogula obulezi	<input type="checkbox"/>
Q4	No transport to the facility Entambura okutuuka kuilwaliro	<input type="checkbox"/>
Q5	Difficult to get permission to go to the facility Olukusa okujja kuilwaliro	<input type="checkbox"/>
Q6	Prefer to go to community healer/TBA Nenda musawo owekiyirugavu	<input type="checkbox"/>
Q7	Attitude of health workers Empisa yabasawo imbi	<input type="checkbox"/>
Q8	Other Ekindi	<input type="checkbox"/>

End – thank the participant for their time.

4. Selected Indicators explained

ANC Attendance: attendance at least once during pregnancy: The proportion of women with a live birth in the last 24 months who were attended by skilled health personnel (doctor, nurse, midwife or auxiliary midwife) for antenatal care at least once while pregnant. [MICS 5.5a, Countdown]

Numerator: Number of women with a live birth in the last 24 months] who were attended by skilled health personnel for antenatal care

Denominator: Number of women interviewed with a live birth in the last [24 months].

Problems accessing health care for self: The proportion of women age 15-49 who reported that they have at least one serious problem in accessing health care for themselves when they are sick”[DHS 9.9]

Numerator: Number of women aged 15-49 who report that they have at least one serious problem in accessing health care for themselves when they are sick

Denominator: Number of women aged 15-49 interviewed

Good health workers' attitude

Numerator: Number of facility users interviewed who reported that medical staff talked politely to them

Denominator: Number of women 15-49 who attended RCH during last 12 months

Stock-Out Levels:

Stock-out levels were computed as aggregated data. From the health Facility Survey, an indicator was obtained to determine the number of times a health facility had stock out of atleast one vaccine. Percentages were computed on the average number of times a sub-district had stock-out levels. These were grouped into low stock-outs for those with less than 50% stock-outs and high stock out sub-districts were above 50%. This was now generalized to the mothers who come from the respective sub-districts, and was used as a proxy indicator to determine the association between complete vaccination and average stock out levels.

5. Maternal and newborn study areas in Eastern Uganda

